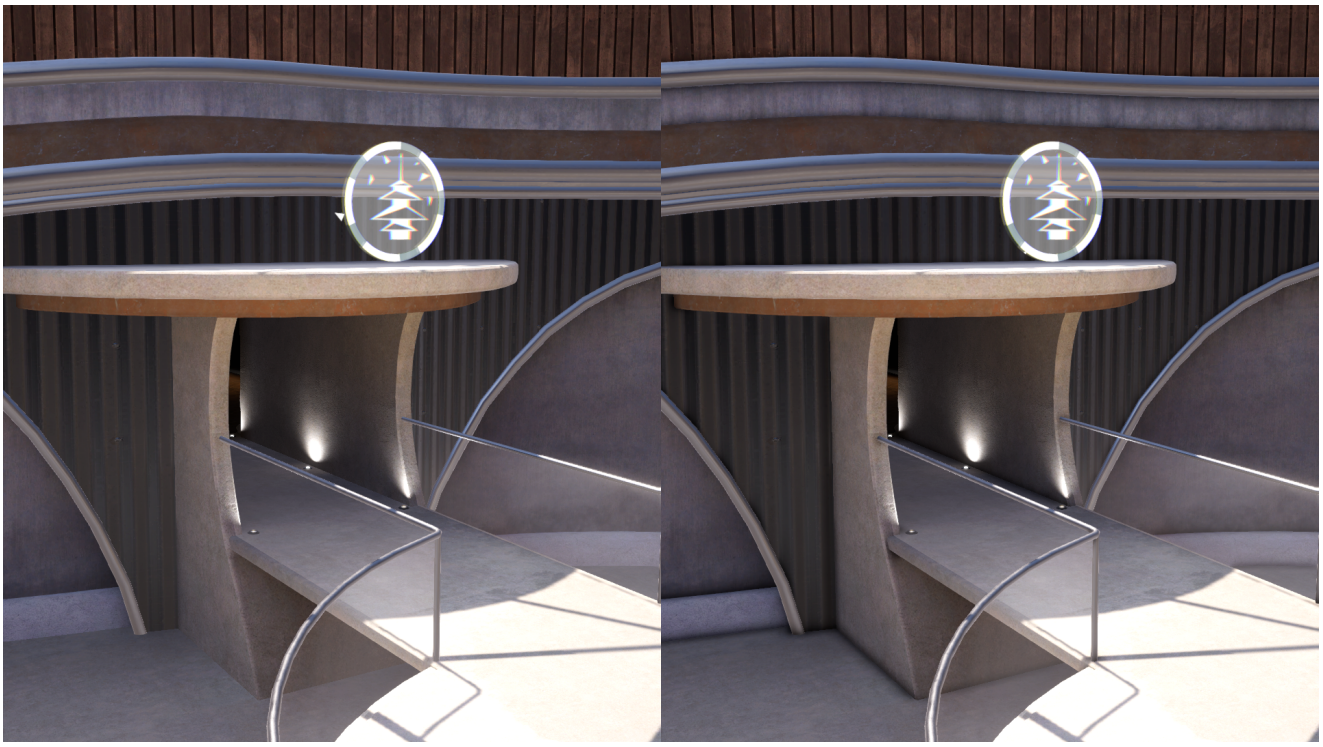
URP GTAO Guide



This document serves as an introduction and guide for the upcoming Ground Truth Ambient Occlusion(GTAO) feature for URP. The feature is currently in a usable preview state, ready for curious users to try out. We are looking to gather feedback before the initial release, and would love to hear what you think.

When you are ready to provide feedback, please take a moment to fill out this survey. For any additional questions or bug reports, please make a post on the discussions thread, or send an email to steven.kent@unity3d.com.

Thanks for your interest in trying out the feature, and for giving feedback.

What is GTAO?

The Ground Truth Ambient Occlusion estimates how much of the hemisphere above each pixel is blocked by nearby geometry, by integrating horizon angles read from the depth buffer. Compared to URP's previous ambient occlusion, it produces more physically-grounded contact shadows with less over-darkening, and it can be denoised with spatial and temporal filtering so it stays clean even at low sample counts. The existing algorithm is preserved, so you can adopt GTAO where you want it and keep the previous look everywhere else.

Enabling GTAO

Setup Project

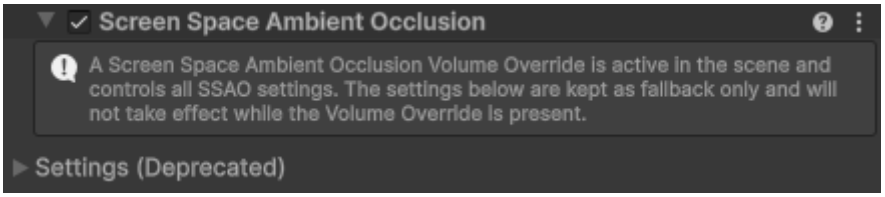
1. Install the latest Alpha version through the Unity Alpha program, at least 6000.7.0a1.
2. Create or load a URP project.

Configure Project

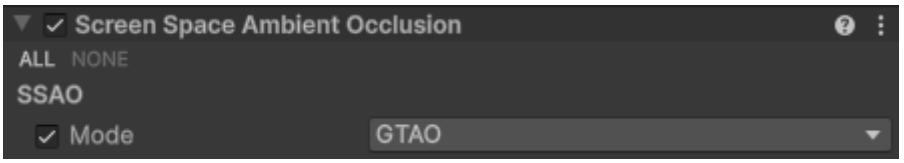
1. Navigate to Project Settings > Player > Other Settings.
2. Under Scripting Define Symbols, add MODERN_SSAO as a new entry. This will make the Screen Space Reflection feature appear in URP's list of Renderer Features.

Add Renderer Feature

1. In your Universal Rendering Data asset, add the Screen Space Ambient Occlusion Renderer Feature. This enables the feature for the given URP Renderer.

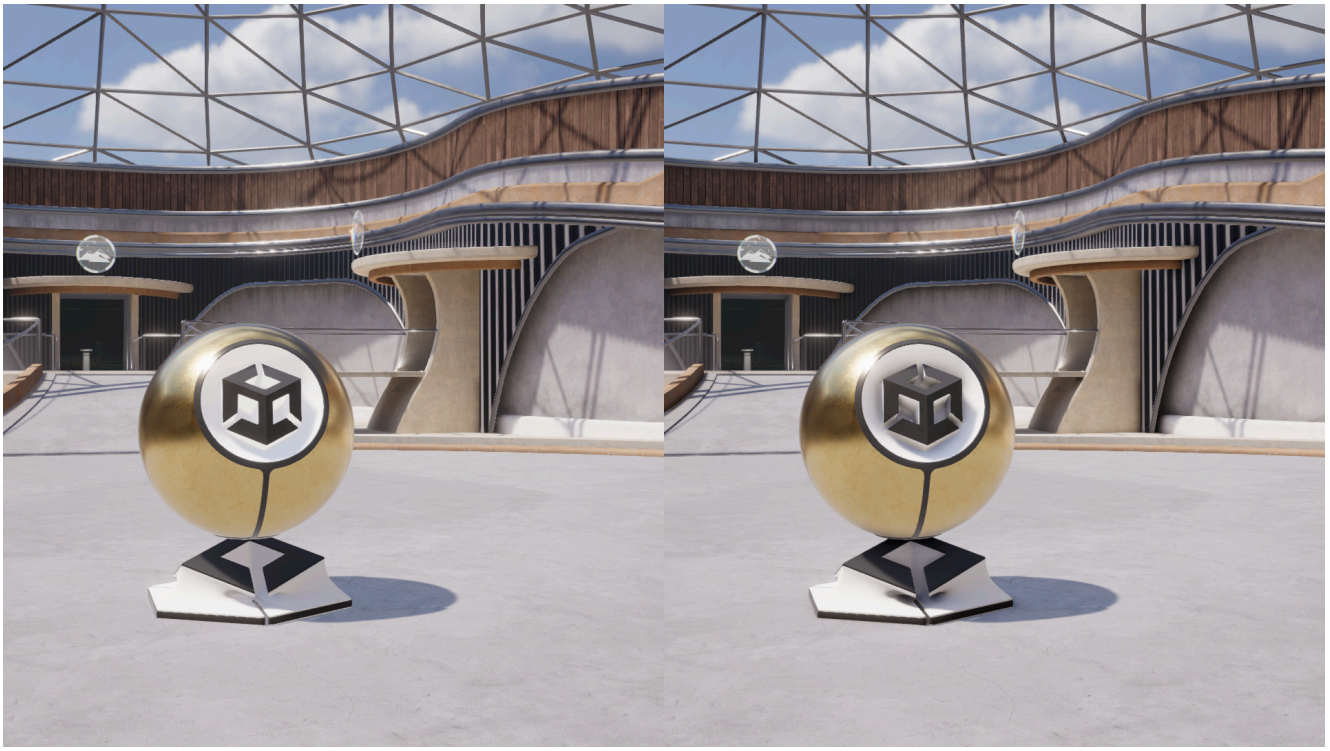


2. In a Volume Component, add a Screen Space Ambient Occlusion Volume override and set the mode to GTAO. This is where you configure the behaviour and quality of Screen Space Ambient Occlusion.



That's it!

You should now see improved ambient occlusion on surfaces.



Configuration

In this section, we describe the settings exposed by the Screen Space Ambient Occlusion feature. Unlike the legacy version, where the effect was configured directly on the Renderer Feature, all of the relevant settings now live in a volume override.

Mode

The Mode setting selects the ambient occlusion algorithm. This choice determines which of the settings below are available:

- **None:** No ambient occlusion is rendered; the feature is disabled.
- **SSAO:** Screen Space Ambient Occlusion using the Alchemy method. This is the cheaper option, and the legacy SSAO implementation. It is the default.
- **GTAO:** Ground Truth Ambient Occlusion. A horizon-based technique that sweeps a number of directions around each pixel and marches several steps along each. It produces more physically grounded, higher quality contact darkening than SSAO, at a higher cost. GTAO also unlocks a compute shader path with temporal accumulation (see below).

Common Settings

The following settings appear in both SSAO and GTAO modes, and are the main controls for the look of the effect:

- **Sampling Method:** The noise pattern used when sampling occlusion. Interleaved Gradient generates a static pattern and is more performant. Blue Noise generates a pattern that varies over time, at a slightly higher cost, producing a more subtle effect when the camera is in motion.
- **Intensity:** Controls the strength of the ambient occlusion effect. Increase this value to produce darker occlusion in creases, holes and surface intersections. The default is 1, and the value ranges from 0 to 5. A value of 0 disables the effect.
- **Radius:** The radius in world-space units around a given point where Unity calculates and applies occlusion. Larger values cover more area, producing broader, softer occlusion, but may reduce performance due to increased texture sampling. This setting should be tuned to the scale of your scene.
- **Falloff Distance:** The distance from the camera up to which ambient occlusion is visible. Beyond this distance, the effect fades out. Use this to skip AO on distant geometry where it isn't noticeable, which can also help performance.
- **After Opaque:** Controls when the SSAO pass runs and how it is composited. This setting has implications for both performance and quality, and is described in detail in the After Opaque section below.
- **Direct Lighting Strength:** Controls how visible the ambient occlusion effect is on surfaces lit by direct light sources. At 0, occlusion only affects ambient/indirect lighting; higher values apply occlusion more uniformly across all lighting, including directly lit areas. This setting has no effect when After Opaque is enabled.

GTAO Settings

The following settings are only available when Mode is set to GTAO:

- **Minimum Radius (Pixels):** A screen-space floor on the world-space Radius. As geometry moves away from the camera, the projected radius shrinks to just a few pixels and the effect would otherwise vanish. This setting guarantees a minimum sampling radius in pixels so AO remains visible at a distance. Larger values keep AO visible further away, but sample a wider screen region. The default is 40, and the value ranges from 1 to 256.

- **Use Compute Shader:** When enabled, GTAO is evaluated using a compute shader instead of the fragment path. The compute path unlocks temporal accumulation, configurable Direction Count and Step Count, and a choice of Spatial Filter. The fragment path instead derives its sample count from the Sample Count setting. Requires compute shader support on the target platform (see Limitations).

- **Spatial Filter:** The filter used to denoise the GTAO result on the compute path. Bilateral is a two-pass, normal-guided filter that preserves edges (the default). Box is a normal-guided box filter with tangent-plane depth rejection.

Quality Settings

The Quality Settings group lets you trade visual quality for performance. The Quality dropdown contains built-in presets - Low, Medium, and High - that configure the sub-settings below for you, plus a Custom option that lets you adjust each sub-setting individually. The sub-settings are only editable when Custom is selected; otherwise they display the values chosen by the active preset. Note that the presets are only applied when the Quality parameter's override checkbox is enabled, and that they affect only the sub-settings relevant to the current mode and path.
The presets configure the following:

Parameter	Low Preset	Medium Preset	High Preset
Downsample	Enabled	Enabled	Disabled
Sample Count	Low	Medium	High
Depth Source (SSAO)	Depth	Depth Normals	Depth Normals
Normal Quality (SSAO)	Low	Medium	High
Blur Quality (SSAO)	Low (Kawase)	Medium (Gaussian)	High (Bilateral)
Direction Count (GTAO)	1	2	4
Step Count (GTAO)	2	4	6

The individual sub-settings are as follows:

- **Depth Source (SSAO only):** The source of the depth and normal data used to evaluate occlusion. Depth uses only the depth buffer and reconstructs normals from it, which is cheaper but less accurate. Depth Normals uses normals from the depth-normals prepass, which is more accurate but requires that prepass to run. GTAO and the Deferred rendering path always use the depth-normals source regardless of this setting.

    - **Normal Quality:** The number of depth texture samples Unity takes when reconstructing normals from depth. Higher quality produces more accurate normals at a higher cost. Only used when Depth Source is set to Depth.

- **Downsample:** When enabled, Unity computes the ambient occlusion texture at half resolution to improve performance. This is cheaper but produces a softer, lower-detail result.

- **Blur Quality (SSAO only):** The blur applied to the occlusion texture to reduce noise. Low (Kawase) is a single-pass blur with the best performance, Medium (Gaussian) is a balanced option, and High (Bilateral) is an edge-preserving two-pass blur that gives the cleanest result at the highest cost. GTAO uses its own filtering (see Spatial Filter) and is not affected by this setting.

- **Sample Count:** The number of occlusion samples taken per pixel. Higher values reduce noise and improve quality at a higher cost. In SSAO mode this maps to 4 / 8 / 12 samples for **Low / Medium / High**; in the GTAO fragment path it maps to the number of marching iterations.

- **Direction Count (GTAO compute only):** The number of directions GTAO sweeps around each pixel. More directions improve quality but increase cost. Ranges from 1 to 8.

- **Step Count (GTAO compute only):** The number of steps GTAO marches along each direction. More steps improve quality but increase cost. Ranges from 1 to 16.

Temporal Accumulation

The Temporal Accumulation group is only available in GTAO mode with Use Compute Shader enabled. It uses information from previous frames to reduce noise and stabilize the effect over time, which is especially useful when running with low Direction/Step counts or at half resolution.

- **Enable:** Enables temporal filtering. When enabled, the sampling pattern is rotated and offset each frame, and the results are accumulated over time. This requires motion vectors, which are added to the frame automatically when this option is on.

- **Ghosting Mitigation:** Controls how aggressively temporal accumulation rejects history to reduce ghosting. Higher values reject more history, which reduces ghosting and trailing artifacts behind moving objects, but can reintroduce noise. The default is 0.5, and the value ranges from 0 to 1.

- **History Length:** Controls how many frames are accumulated. Higher values produce smoother, more stable results, but can increase ghosting. The default is 0.9, and the value ranges from 0 to 1.

After Opaque Toggle

The After Opaque setting in the volume override controls when the SSAO pass runs, which has implications for both performance and quality:

- **After Opaque disabled (the default):** The SSAO pass runs before the opaque lighting pass. This allows occlusion to be integrated into the shading model, affecting both indirect and (via Direct Lighting Strength) direct lighting, and produces the highest quality result.

- **After Opaque enabled:** The SSAO pass runs after the opaque pass, and the occlusion is multiplied onto the final opaque image. This is generally more performant - particularly on tiled/mobile GPUs - but is less accurate, because occlusion is applied after the shading model has already been evaluated. In particular, Direct Lighting Strength has no effect in this mode, and already-lit or emissive surfaces can be darkened. We recommend this setting mainly for low-end devices.

Troubleshooting

Below are some common pitfalls you may encounter while using Screen Space Ambient Occlusion, and advice on how to solve them. Check the Limitations section if your issue isn't listed.

- *Ambient occlusion is missing:* First make sure the feature is set up correctly:
    - Ensure the Screen Space Ambient Occlusion Renderer Feature is added to the Universal Renderer your camera uses.
    - Ensure the Enable toggle is on, and that its override checkbox (to the left of the setting) is ticked.
    - Ensure Intensity, Radius and Falloff Distance are all greater than 0.
    - Ensure the Volume that contains the override actually affects the camera: it should be set to Global, or its collider and blend distance should reach the camera, and its layer must be included in the camera's Volume Mask. A higher-priority volume may also be overriding the values.

- *Ambient occlusion looks noisy or grainy:* Raise the Quality preset, or in Custom mode increase Sample Count. In SSAO mode, set Blur Quality to High (Bilateral). In GTAO compute mode, increase Direction Count and Step Count, or enable Temporal Accumulation. Disabling Downsample also reduces noise, at the cost of performance.

- *Changing the Quality preset doesn't change anything:* Presets are only applied when the Quality parameter's override checkbox is enabled. The individual sub-settings under Quality Settings are only editable when the preset is set to Custom.

- *Performance is bad:* The most effective way to recover performance is to lower the Quality preset. Beyond that, enable Downsample, lower Sample Count, and reduce Radius, which lowers the amount of texture sampling. In GTAO mode, lower Direction Count and Step Count, and consider disabling Use Compute Shader and Temporal Accumulation.

Limitations

Below is a list of current limitations, some of which may be addressed in future releases.

- Screen Space Ambient Occlusion is, by definition, a screen-space technique: it can only account for occlusion from geometry that is visible in the depth buffer. Occluders that are off-screen or hidden behind other surfaces do not contribute, which can cause occlusion to weaken or disappear near the screen edges, or when a nearby occluder is itself hidden from view.

- GTAO always uses the depth-normals prepass for its depth and normal data and applies its own filtering. As a result, the Depth Source, Normal Quality and Blur Quality controls apply to

SSAO mode only and have no effect in GTAO mode. Enabling GTAO forces the depth-normals prepass to run.

- Temporal Accumulation, configurable Direction Count / Step Count, and the Spatial Filter selection are only available on the GTAO compute path. On platforms that do not support compute shaders, enabling **Use Compute Shader** falls back to the fragment path, and these options have no effect. The editor displays a warning when compute shaders are unavailable.
- Temporal Accumulation relies on motion vectors and history reprojection. Enabling it automatically adds motion-vector generation to the frame, which has its own performance cost. Because it reprojects from previous frames, fast camera or object motion and disocclusions can still introduce noise or ghosting; the Ghosting Mitigation and History Length settings trade these two artifacts off against each other.

Known Issues

Below is a list of known issues and bugs. If you encounter any issues or bugs not listed here, please let us know!

- The Screen Space Ambient Occlusion override is not currently supported within the Default Volume. We are working on fixing this issue while developing improvements for the overall Volume UX workflow.

Custom Shader Support

The SSAO upgrade introduces no changes to existing behaviors; everything continues to function exactly as it did previously.

To *receive* Screen Space Ambient Occlusion, custom shaders must declare the global _SCREEN_SPACE_OCCLUSION keyword, like so:

```
C/C++
Pass
{
    Name "ForwardLit"
    Tags { "LightMode" = "UniversalForward" }
    HLSLPROGRAM
    ...
    #pragma multi_compile_fragment _ _SCREEN_SPACE_OCCLUSION
    ...
    ENDHLSL
}
```

A working implementation of this can be found in com.unity.render-pipelines.universal\ShaderLibrary\AmbientOcclusion.hlsl, which custom shaders may choose to include.

FAQ

Does GTAO replace URP's existing SSAO?

No. The existing algorithm is kept as the SSAO mode and your current projects render exactly as before. GTAO is an additional, higher-quality option you opt into per scene.

Do I need compute shaders to use GTAO?
GTAO runs through either a raster fallback or a compute path. The compute path is recommended and is required for temporal filtering and the advanced spatial filters.

Does GTAO require motion vectors?
Only the temporal filter does — it needs motion vectors to reproject the previous frame. Spatial-only GTAO does not.

Can I still configure SSAO from the Renderer Feature?
While it is still possible to use the Renderer Feature for configuration, we keep these settings primarily as a reference or fallback to ensure existing projects maintain their current look during migration. Please be aware that these parameters remain subject to adjustment as we continue to polish the Volume-based workflow in the future.

How does GTAO affect performance?
GTAO costs a little more than SSAO. You can dial it in with quality presets, lower direction/step counts, downsampling, and your choice of spatial filter, and lean on temporal accumulation to keep quality high at a low per-frame cost.